

Appendix W

Survivability Testing

W-1. Overview of survivability testing

a. This appendix provides guidance on planning, executing, and reporting survivability testing to include E3, nuclear, biological, chemical, contamination survivability (NBCCS), and soldier survivability testing. This information differs from the live fire survivability testing discussed in appendix S in that it discusses survivability concerns related to the electromagnetic, nuclear, and soldier environments. Survivability analysis and testing are included throughout the system design and verification process and conducted at the material, piece part, component, equipment, subsystem, system, and platform levels.

b. Survivability testing is a unique form of testing conducted primarily during DT, however, elements such as Electronic Warfare (EW) may be included in the OT. The scope of testing is driven by applicable regulations and may be tailored based on the customer requirements. The primary customer for survivability testing is the Army PM working in coordination with the T&E WIPT and system evaluator. Other customers may include other Army elements, joint Services, and private industry.

c. The testing discussions in this section build on the evaluation discussion provided in chapter 5 and appendix I, how testing is conducted and considerations in conducting various forms of survivability testing.

W-2. Survivability testing definitions

a. Electromagnetic and environmental effects (E3) refers to the impact of the electromagnetic environment upon the operational capability of military forces, equipment, systems, and platforms. It encompasses all electromagnetic disciplines, including electromagnetic compatibility (EMC); electromagnetic interference (EMI); electromagnetic vulnerability (EMV); electromagnetic pulse (EMP); hazards of electromagnetic radiation to personnel; ordnance, and volatile materials; and the effects of natural phenomena (lightning and static electricity). Generally accepted E3 requirements are discussed in MIL-STD-464, DOD Interface Standard Electromagnetic Environmental Effects Requirements for Systems.

b. The materiel survivability aspects are addressed through NBCCS. The characteristics that NBCCS testing must address are hardness, decontaminability, and compatibility. NBCCS is required for mission essential systems and equipment (see AR 70-75). DPG conducts biological, chemical, and contamination survivability testing and WSMR conducts nuclear (including thermal blast), HEMP, and nuclear radiation testing. Decontaminability and hardness require live agent testing in the DPG chemical surety labs. Compatibility requires human test participants (usually military personnel) to demonstrate use of the system while in MOPP IV in a simulated chemical attack environment.

c. Testing for soldier survivability includes a range of analyses and test types, both survivability specific and not survivability specific, depending upon the type of system. When planning soldier survivability testing, the potential effects of the system in its operating configuration and environment on soldier survivability must be analyzed in order to determine those data required. For example, if a system has a potential reflective surface, such as a sight or other lens, the potential for increasing the visual signature of the soldier and therefore his or her accessibility as a target must be determined. The goal is to provide data for proper system use and design to maintain or increase the ability of the soldier to perform the mission while avoiding detection by the enemy. Light levels required to operate a system may require consideration and testing if the system mission involves blackout conditions. The effect of a system on the soldier's ability to perform the mission without decreasing his or her ability to avoid detection by the enemy must be analyzed and appropriately tested.

W-3. Survivability test concerns

In planning the scope and type of survivability tests, the maturity of the system design and materials must be considered. Survivability requirements must be considered throughout system development; however, if the system is in breadboard or brassboard stages, it may be more appropriate to conduct analyses of survivability elements based on similar or past systems, vice actual hardware testing. If a system requires modifications in order to meet survivability requirements, these could involve both design and material changes. Therefore, as stated in AR 70-75 and the Defense Acquisition Guidebook, it is strongly desirable to begin the survivability assessment process early because deficiency corrections later in the system's acquisition process may involve costly decisions requiring system re-design.

W-4. Survivability testing platforms and interfaces

The operating environment and accurate physical identification of the configuration of the system under test must be considered in planning survivability testing, and must be replicated in testing to the fullest extent possible. In most system survivability tests, any platform mountings, interfaces, and connecting points must be tested along with the system under test (SUT) itself. In some cases, the host platform (where applicable) will be included in the analyses and/or the tests. In some cases, a mockup or simulated host platform or interface can be included in the tests. The

survivability requirements of the host platform (where applicable) should be reviewed as part of test planning to maximize compatibility between those requirements and those of the SUT. Usually, the survivability requirements for the SUT should be no more stringent than those of the host platform system.

W-5. Destructive nature of survivability testing

The cost of the SUT, the number of test items available, and the destructive nature of many survivability tests must be considered in test planning. If items are costly and available systems few in number, then a series of survivability tests may be desired to be conducted using the same test items. Those survivability tests that are least destructive (such as, EMI, EMC, and signature effects) should be conducted earliest, while the most destructive tests (that is, high-altitude electromagnetic pulse (HEMP), lightning, and NBCCS) should be conducted last. The probability of a catastrophic or degrading effect of each test and the expected failure modes and robustness of the SUT itself should be considered, as should whether the system could be refurbished between tests.

W-6. Survivability testing of software systems

Both hardware and software must be included during survivability testing. A full-up system including mature software should be tested in most survivability tests so that the system can be operated after each test in order to determine any degradation.

W-7. Inclusion of a standard item in survivability testing

In cases when survivability requirements are stated relative to the current, standard, fielded system to be replaced, consideration must be given as to how that data will be obtained. If there are valid data on the current standard, fielded system, then those data can form the basis for comparison. If there are no such data, a standard item should be included in the applicable survivability tests for comparison to support analysis of the impact of any survivability failures. For example, if a test system is not survivable in one or more areas and the standard system is also not survivable, then the importance of that failure can be viewed with a different perspective than if a test system survivability were worse than the system it could replace.

W-8. Electromagnetic interference/electromagnetic compatibility survivability testing

Electromagnetic interference/electromagnetic compatibility testing is conducted to ensure a system will operate within an intended environment or meet a system control specification. An electromagnetic system will both radiate and conduct emissions through antenna elements and connected cabling causing interference to neighboring and distant equipment. In this situation, a system operates as a source of EMI. A similar system may also be susceptible to radiated and conducted emissions either from neighboring or distant equipment. During this condition, the system or item is a victim of EMI.

a. Generally accepted requirements and procedures for testing are provided in MIL-STD-461, DOD Interface Standard Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment. Test methods and requirements may be tailored to the procurement of the individual system or platform when analysis reveals that the requirements are not appropriate.

b. Although a system meets all specifications, it is ultimately important that the system be compatible with the neighboring fielded equipment that will be used in the operational environment. For example, if a motor is operated in close proximity to a radio, it is important to ensure this configuration is tested in various modes of operation. This is referred to as EMC testing. Often it may be difficult to determine the full extent of these various configurations, or large combinations of equipment may exist. When these conditions apply, the testers may consider selecting some worst case conditions based on an analysis of the situation.

c. EMI/EMC may also affect safety-critical functions such as firing circuits or operation of hazardous electro-mechanical equipment. EMI/EMC testing should be considered early in the development process since identified problems may require design changes impacting program cost and schedule.

W-9. Lightning effects survivability testing

The characteristics and causes of lightning and lightning effects are widely studied and will continue to be researched. Designers must be aware of the potential consequences of lightning effects and include appropriate measures for protection, such as grounded equipment and arrestors. The effects of lightning on Army equipment will range from no effect, mild disruption, to complete unrecoverable damage. Special consideration for lightning testing should be given to sensitive electronic systems, ordnance, and tall antenna/masts that will be deployed to areas with high occurrence of thunderstorms (that is, high keraunic number), high altitude above sea level, or systems that will be located in open terrain. Additional considerations may include electrical shock to personnel that may be required to operate equipment through an electrical storm. Lightning tests are conducted both for direct strike (that is, physical effects that often include burning, eroding, blasting, and structural deformation as well as the high pressure shock waves and magnetic forces produced by the associated high current) and near strike lightning (that is, hazard resulting from electromagnetic fields). Generally accepted levels are defined in MIL-STD-464.

W-10. Electrostatic discharge control survivability testing

The system will be designed to control and dissipate the build-up of electrostatic charges caused by precipitation static (p-static) effects, fluid flow, air flow, launch vehicle charging, and other charge generating mechanisms to avoid fuel ignition and ordnance hazards, to protect personnel from shock hazards, and to prevent performance degradation or damage to electronics.

W-11. Electromagnetic pulse survivability testing

a. Electromagnetic pulse (EMP) is the electromagnetic radiation from a nuclear explosion caused by Compton-recoil electrons and photoelectrons from photons scattered in the materials of the nuclear device or in a surrounding medium. The resulting electric and magnetic fields may be coupled with electrical/electronic systems to produce damaging current and voltage surges. The EMP may also be caused by non-nuclear means. For more information, see AR 5-12, Army Management of the Electromagnetic Spectrum.

b. During a high altitude nuclear detonation, gamma rays are released that set high energy electrons into motion. These electrons are subsequently deflected by the electromagnetic belt surrounding the earth and an electromagnetic pulse is created. This deflection can generate a voltage pulse of 50,000 V/m at a point 300 miles from the detonation, with a rise time of approximately 5,000 V/s. This is much more severe than a lightning strike, which has a field density of 3 V/m, 6 miles from point of discharge, and a rest time of 600 V/s. Because of the large magnitude of the voltage and frequency spectrum of an EMP, there are basically no "off-the-shelf" R-C or L-C filters that can effectively reduce or eliminate such an EMP.

c. Metal oxide semiconductor circuits and small area geometry semiconductors are especially vulnerable to the EMPs. Because of this vulnerability, effective suppression techniques and protective devices must be used to protect against EMP.

W-12. Electromagnetic vulnerability survivability testing

a. The characteristics of a system that cause it to suffer a definite degradation (that is, incapability to perform the designated mission) after being subjected to a certain level of effects in an unnatural (that is, manmade), hostile environment. Electromagnetic vulnerability (EMV) measures the system's incapacity to perform in the presence of hostile electronic attack. EMV is measured only in its own operational environment (either actual or simulated) and under conditions that take into account: (1) how susceptible the system is; (2) how easily it can be intercepted by hostile intercept and direction-finding activities; and (3) the nature and extent of the hostile EW threat. For additional information, see AR 5-12.

b. The Battlefield Electromagnetic Environments Office (BEEO) as an element of HQ, DTC, develops, maintains, and operates the database for spectrum management, per AR 5-12.

W-13. Electromagnetic radiation hazard survivability testing

The hazards of electromagnetic radiation to fuels, electronic hardware, ordnance and personnel are normally segregated into three categories.

a. A system will comply with current national criteria for protection of personnel against the effects of electromagnetic radiation. Test, analysis, and inspections must verify compliance with established procedures and guidelines. Hazards of electromagnetic radiation to personnel (HERP) relates to the fact that the body absorbs radiation, which can result in significant internal heating without the individual's knowledge. Such a situation may potentially result in a deleterious effects on an individual's metabolic process. Therefore, criteria have been established with the regards to acceptable limits. HERP testing establishes the potential exposure levels emanating from a device or system.

b. Hazards of electromagnetic radiation to ordnance (HERO) relates to the susceptibility of ammunition and other explosive devices to electromagnetic fields emanating from other devices or system(s). All explosive items that contain electrical initiating devices such as exploding foil initiators for example or similar items may initiate when exposed to high levels of electromagnetic radiation. Levels currently established are primarily based on possible shipboard transport or handling on ship and those levels found at U.S. military bases throughout the world. ATEC's DTC at WSMR and RTTC has the capability to conduct HERO on munitions although the Navy has the established capability for large-scale test items such as is conducted on armed helicopters. Lesser radiation levels, under those established for personnel safety, may be included during these tests to determine susceptibility of ammunition during preparation and uploading ammunition on an aircraft by personnel. Testing normally involves a requirement for specially configured items that provide a minimum hazard to personnel and equipment.

c. Fuels must not be inadvertently ignited by radiated electromagnetic energy. Hazards of electromagnetic radiation to fuel (HERF) relates to the potential for fuels to initiate by radiated energy from onboard emitters and other external sources. Test, analysis, and inspections must verify compliance with established procedures and guidelines. Radio frequency (RF) energy can induce currents into any metal object, possibly resulting in a spark across a gap between conductors and resulting in ignition of fuel.

W-14. Information assurance survivability testing

Information assurance (IA) is becoming an increasingly higher threat area and test scope and particulars will vary

based on the SUT. Testing will be performed in order to evaluate this emerging threat. Testing will capitalize on the benefits and lessons learned from private and Government organizations to develop test methods and scenarios for identification of IA issues.

W-15. Nuclear weapons effects survivability testing

The nuclear effects occurring within the first 60 seconds of a nuclear detonation (initial nuclear radiation (INR), air blast, and thermal radiation, electromagnetic pulse (EMP)) are addressed under nuclear weapons effects (NWE). The “nuclear” effects occurring after 60 seconds of a nuclear detonation (neutron induced gamma radiation and fallout) are addressed as residual nuclear contamination under NBC effects. NBC survivability is approached in terms of mission effectiveness by establishing an NBC defensive architecture appropriate for the system. Personnel survivability aspects are addressed by employing NBC defensive equipment and tactics, techniques, and procedures (TTP) to ensure soldier survivability. The material survivability aspects are addressed through NBC contamination survivability.

W-16. Electronic warfare survivability testing

WSMR performs directed energy laser vulnerability/susceptibility, high power microwave, and millimeter-wave testing using both contractor test requirement methodologies and classified criteria. The EPG provides various ground jammers for testing of tactical radios and navigation systems. The EPG also developed and utilizes in a limited manner along with the OTC simulated jammers. The applicability and use of simulated jamming should be considered to support testing when frequency clearance is a problem or frequency spectrum limitations prevail.

W-17. Signature effects survivability testing

Most requirements will pertain to the SUT being no more detectable or having no greater signature or footprint than the standard, fielded system. If valid data on a comparison system are not available, consideration should be given to including a comparison system in these tests. The operating environment of the system (for example, battlefield conditions, foliage, terrain, and mobility) should be considered in planning the test conditions. Footprints and detectability of a system will vary with its environment in the field (for example, stationary, moving, weather effects, light and atmospheric conditions); thus, a range of environment types and field conditions should be tested.

W-18. Directed energy survivability testing

Directed energy testing is an emerging area of concern with various requirements based on the SUT. Testing is conducted by WSMR, NM.

W-19. Nuclear, biological, and chemical contamination survivability testing

DPG, UT, conducts NBCCS testing, as described in AR 70-75. NBCCS testing must address the three elements of decontaminability, hardness, and compatibility. Decontaminability and hardness require live agent testing in the DPG chemical surety labs. Compatibility requires human test participants (usually military personnel) to demonstrate use of the system while in MOPP IV in a simulated chemical attack environment.

W-20. Functionality after survivability testing

Depending upon the SUT and its unique performance requirements and features, several measures may be required in order to determine the effects of survivability testing. In survivability test planning, the key performance indicators of the system should be identified and measured in a new system as a baseline. Then the series of survivability tests should be conducted, most likely on separate test items or in a series from least destructive to most destructive, each one followed by a visual inspection and by re-measuring of key performance indicators for that system. The purpose, mission parameters, operating procedures, and ILS concept of the system in the field must be considered when analyzing survivability results. For example, field procedures during decontamination may allow for some components or parts of the system to be removed and disposed of. If those components or parts were not NBC survivable, those results would not indicate that the entire system is not survivable. Another example is that some degradation in certain functions may be allowable, and the system could still complete its primary mission, thus indicating adequate survivability.

W-21. Test sites and facilities for survivability testing

The following is a brief description of test sites and associated facilities available within the Army for conducting survivability testing discussed in this section.

a. White Sands Missile Range, NM, is the largest overland missile range in the DOD and provides a great deal of capability in the survivability/vulnerability testing area. These test capabilities cover most requirements and, with a central location, have the benefit of greatly reducing logistics costs. The following major facilities are located at the WSMR.

(1) The Electromagnetic Radiation Effects Test Facility is the primary test facility for providing MIL-STD-464 environments and conducting EMC, both intra- and inter-system, and EMP (such as, personnel, airborne, and p-static). The electromagnetic radiation effects (EMRE) facility coordinates and maintains multiple transmitters that are capable

of producing approximately 200 V/m from 1 MHz through 48 GHz, three 70-ton turntables that are used to dynamically orient the SUT, and a large electromagnetic quiet room for making system emission measurements. The facility maintains all of the necessary instrumentation and support equipment required for this testing. WSMR also operates facilities for conducting EMP as well as a direct and near strike lightning facility for conducting tests in accordance with MIL-STD-2169B.

(2) WSMR provides test capabilities for nuclear effects of electronics to include neutron, gamma total dose, gamma dose-rate, blast, and thermal effects. Along these lines, WSMR maintains an extensive electronic microcircuit nuclear response database of electronic component automated test and characterization capabilities in the Army, and support for electronic obsolescence and life cycle issues through the Radiation Tolerant Source of Supply Center (RTASSC). In addition, WSMR has been provides design consultation and guidance, and performing nuclear system modeling, simulation and predictions using electrical engineering techniques. The following combination of facilities (many conforming to ISO 9000) are capable of simulating the system's nuclear requirements as generated by the U.S. Army Nuclear and Chemical Agency (USANCA).

(a) Blast and thermal effects that may be experienced following a nuclear event can be simulated in the Large Blast Thermal Simulator (LBTS). The LBTS simulates the blast and thermal effects associated with a nuclear weapon detonation on an integrated nuclear battlefield and is capable of varying shock overpressures and duration independently. The world's largest airblast simulator is located at WSMR and can test systems as large as the UH-60 Blackhawk. It can simulate realistic blast waves from 10 to 10,000 kilotons (kT) and also peak static overpressures from 1 to 30 pounds per square inch (psi). The LBTS can also provide non-ideal airblast environments. The Solar Furnace Facility (SFF) provides thermal radiation testing of material. The SFF uses a very large mirror system to collect solar energy and then focus it through a computer-operated shutter onto the test object. Thermal simulations of environments between 10 and 1,000 kT can be provided.

(b) Initial nuclear radiation consists of the following:

- *Neutron Fluence Effects.* The Fast Burst Reactor (FBR) produces neutron fluence test environments for semiconductor devices, electronic components circuit card assemblies, shop repairable units (SRUs), line replaceable units (LRUs), subsystems and systems. The FBR is located inside a 15 meter (m) by 15m by 6 m test cell that has a 4 m by 4 m entrance. Every Army system with a nuclear survivability requirement has been tested at the FBR as well as more than 6,000 different semiconductor devices.
- *Gamma Dose-Rate Effects.* The Relativistic Electron Beam Accelerator (REBA) and the Linear Electron Accelerator (LINAC) provide environments for testing gamma dose-rate effects. The REBA is particularly suited for small systems or LRUs. The REBA provides a uniform test environment for threat level validation and engineering gamma dose rate testing. The LINAC is used for very small articles such as circuit boards. For large systems, gamma dose rate is performed at the High Energy Megavolt Electron Simulator (HERMES II), which is located 240 miles north of the WSMR main post area.
- *Gamma Total Dose Effects.* The Gamma Radiation Facility (GRF) is the only DOD large gamma total dose test facility. Through the use of 1 to 13 large cobalt 60 sources, the GRF is capable of providing between 1000 rad (silicone) per second (rad (Si)/s) to less than 0.1 rad (Si)/s. Test items as large as tanks are tested in a test cell that is 6 m by 13 m by 5 m. Every Army system with a requirement has been tested at the GRF as well as more than 5,000 different semiconductor devices. The GRF can provide a vertical environment for testing of airborne radials and sensors. WSMR also operates the Space Radiation Test Facility (SRTF) for gamma dose and enhanced low dose rate sensitivity (ELDRS) testing. The SRTF provides unique testing of semiconductor devices and objects as large as 65 ft² and is also certified under ISO 9002.

(c) Semiconductor Test Laboratory (STL) is used for electrical parametric and post-test evaluation of semiconductor devices and components. WSMR uses automated testers to evaluate radiation effects on semiconductor devices and components. The STL is connected by an air-vacuum transfer system to all radiation facilities for quick transfer to test devices/components. The STL provides ATEC's DTC and DOD a unique capability and has characterized more than 6,000 devices and components. Nuclear radiation survivability is achieved at the device/component/circuit level.

(3) WSMR uses three methods for electronic warfare (EW)/directed energy (DE) testing. The first is the Pulsed Laser Vulnerability Test Facility (PLVTS), which is the largest CO₂ laser in the USA. The second method is an arrangement WSMR has with the Air Force Research Laboratory (AFRL) at Kirtland Air Force Base, Albuquerque, NM. The AFRL is the prime developer for high power microwave technology and the memorandum of agreement allows for the use of the latest technology on WSMR proper. The third is millimeter-wave testing at the EMRE facility.

b. Electronic Proving Ground (EPG), located at Fort Huachuca, AZ, is the Army developmental tester for C4I systems. The EPG facilities focus on supporting testing, modeling, stimulation and simulation for E3 requirements, with special emphasis on C4I. Key facilities include the following:

(1) The Blacktail Canyon EMI/Transient Electromagnetic Pulse Emanation Standard (TEMPEST) Facility is equipped with indoor and outdoor facilities and equipment to conduct EMI and EMC testing in accordance with MIL-STD 464. EPG is also certified for conducting TEMPEST testing. Four indoor anechoic test chambers are

available with a maximum size of 35 ft by 14 ft by 14 ft. EPG also operates a Tem/Reverberation (TEM/REV) chamber that will fully immerse a system in a wide frequency range to quickly expose system problems.

(2) Tactical Radio and Force XXI Battle Command Brigade and Below (FBCB2) Test Bed facility was established to investigate EMI and EMC issues with tactical radio systems and their platforms. Testing conducted includes co-site EMI/EMC, and desensitization. The tactical radio test bed has the ability to setup a small to medium lay-down of emitters generating a ground truth RF environment for the item under test. The FBCB2 test bed may deploy over 100-instrumented nodes throughout the Fort Huachuca reservation and surrounding areas representing slices of tactical units dispersed over realistic tactical operational distances.

(3) Electromagnetic Environmental Test Facility (EMETF) develops and deploys models, simulations, stimulation and data collection (hardware/software) to aid in E3 investigations and tests. Systems to conduct real-time monitoring and collection of data transmitted to/from equipment under test are continuously developed to meet changing customer requirements. EPG's "tester's tool box" represents a totally unique Army asset supporting all phases of live, virtual, and constructive testing. Items of the tool kit include the Multi Functional Data Collector (MFDC), ORION, and the STARSHIP. The MFDC will collect and stimulate ground truth wide area network (WAN) and local area network (LAN) data of various formats. The ORION will assess a system's ability to operate in the intended E3 environment, including threat forces, and assess the influence of these environments. The STARSHIP is a test control center that provides command, control, and status display of various data collection hardware devices of the EPG, OTC, ATC, and Joint Global Positioning System Combat Effectiveness (JGPSCE).

(4) The EPG currently uses a commercial network vulnerability scanner to provide automated, network-based security assessment and policy compliance evaluation for IA capabilities. The scanner performs both scheduled and event-driven probes of network communication services, operating systems, routers, e-mail, Web servers, firewalls, and applications, to identify system weaknesses that could result in unauthorized network access. It generates reports ranging from executive-level trend analysis to detailed step-by-step instructions for eliminating security risks, including automatic links to vendor Web sites for software patches. The risk management approach measures the following three areas:

- NETWORK ARCHITECTURE—including servers, firewalls, authentication controls, encryption engines, modem pools, Remote Access Server (RAS) services, routers, printers, and connections to other organizations.
- SECURITY POLICY ENFORCEMENT—confirms proper configurations, ensures that users are not by-passing official policy and that all systems are reasonably secured against cyber attack.
- SECURITY DATA CORRELATION—comprehensively detects inter-related network-based vulnerabilities, learns from vulnerabilities detected in previous scans, and builds on this knowledge to discover additional vulnerabilities that would otherwise go undetected.

c. Aberdeen Test Center (ATC), located at Aberdeen Proving Ground, MD, provides nuclear and electromagnetic survivability test facilities needed for general purpose and automotive systems testing.

(1) *Initial Nuclear Radiation (INR).*

(a) *Neutron effects.* The Army Pulse Radiation Facility (APRF) has a mobile, fast-burst reactor for testing of electronics against neutron effects. It is capable of producing self-limiting, high-yield, short-duration pulses or steady-state nuclear environments. Items can be located close to the reactor or outdoors at ranges of up to 2000 meters. For higher exposures, items of limited size may be located inside the reactor. The duty cycle of the pulse reactor for pulsing experiments is typically four to five pulses per 9-hour workday. Operating in the steady-state mode, the pulse reactor is capable of continuous operation up to 8 kilowatts and short ramp operations as high as 150 kilowatts.

(b) *Gamma total-dose effects.* APRF can supply gamma rays, which provide long-term effects and damage electronics through ionization. APRF can also provide a more realistic environment through use of the reactor to provide gamma dose in combination with neutrons. APRF has two Cobalt 60 irradiators for producing 5,012 to 377,004 rad (silicone) per hour.

(c) *Gamma dose-rate effects.* In addition to damaging electronics through permanent ionization, gamma rays cause transient currents in electronic systems. The transients are proportional to the dose rate, and are usually expressed in rad (Si)/s. These transients may cause temporary damage (that is, latchup) or permanent damage (that is, burnout). APRF has a Physics International (PI) Model 538 flash x-ray (FXR) machine to simulate the prompt-gamma pulse of a nuclear weapon burst. Typical pulses are 87 nanoseconds (ns) full-width at half max (FWHM), with gamma dose rates of up to 4.6 by 1,011 rad (Si)/second or 1.0 by 1,012 rad (Si)/s in pinched beam mode at the faceplate and a rise time of approximately 30 ns. The FXR is movable along its track over a range time of 7 meters, and can be operated independently or adjacent the pulse reactor. In the latter position, the pulse reactor can be positioned in front of the FXR so that both machines can be operated in a combined sequence to simulate the complete INR environment. Typically, between four to six FXR pulses are possible per hour. Considerable flexibility exists in dose rates, pulse widths, and neutron fluence to simulate specific scenarios over practical exposure volumes. A combined environment allows a higher fidelity test than possible by exposing the SUT to the environments separately, since the nuclear threat is intrinsically a combined environment.

(2) *Electromagnetic Interference Test Facility (EMITF).* ATC operates one of the largest double-walled shielded

enclosures in the USA (94 ft by 60 ft by 16 ft enclosure with 16 ft by 16 ft access doors). This design provides a high degree of attenuation to magnetic (H-Field), electric (E-Field), and Plan Wave Fields to assure excellent isolation from the outside electromagnetic environment. This isolation is required to successfully conduct EMI/EMC testing of electrical, electronic, and electromagnetic equipment. The size and structural integrity are features that allow the ATC to primarily conduct testing of large and heavy pieces of equipment and complete systems such as Army enclosures, tanks, generators, portable shielded enclosures, and component bench testing.

(3) *The ATC EMITF*. The ATC EMITF utilizes a computer-controlled data acquisition system; presently covering the frequency range from 16 Hz to 40 GHz to measure and record radiated and conducted emission test data. The data can be provided in various forms to support customer requirements. Frequency synthesizers covering the frequency range from 16 Hz to 40 GHz are used to provide the signal to drive the power amplifiers used to conduct the electromagnetic susceptibility tests. The synthesizers can be operated manually or swept in continuous, step, or manual mode. A computer-controlled radiated and conducted susceptibility system is capable of providing signals having field intensity levels of 200 volts (V) per meter at frequencies up to 40 GHz. Spectrum analyzers are available to conduct spectrum analysis, ambient surveys, and frequency response tests of filters, and amplifiers. EMI-free metered electrical load banks are housed in the EMITF to provide electrical loads for testing engine-driven power generators. One load bank can provide resistive or reactive loads adjustable from 0 to 200 kilowatts per kilovolt amperes (kW/kVa), 60 or 400 Hz, 120/208/220/480 V, single or three-phase, with adjustable power factors. A second load bank provides resistive loads adjustable from 0 to 2,000 amperes, at up to 30 V DC.

d. Infrared (ir) and RF survivability are usually lab bench tests that are nondestructive and require simulation of opposing force detection methods. Acoustic effects testing records the decibel levels of the operating system and compares this to human hearing capabilities over a range of distances. Subjective ratings and comments such as those obtained in human factors testing can also be used to indicate perceived acoustic signature. Acoustic signatures may require analysis with consideration to other acoustics in the operating environment. In visual signature testing, detection attempts must be made over a range of conditions and distances simulating field environments. Opposing force detection methods also must be simulated (for example, night vision goggles and thermal sights).

e. The Redstone Technical Test Center (RTTC), located near Huntsville, AL, at Redstone Arsenal facilities were developed for weapon systems and specialize in the test of missile systems. Indoor and outdoor facilities are capable of supporting small to large size test items. Test stands are available to ensure proper testing in the free field environment. RTTC can conduct automated EMC/EMI testing in accordance with MIL-STD-464. RTTC also has facilities for conducting direct-strike lightning tests. EW, ESD, MASINT, and DOD-STD-2169A HEMP testing can also be conducted.

f. Dugway Proving Ground West Desert Test Center (WDTC) is located in the Great Salt Lake Desert, approximately 75 miles southwest of Salt Lake City, UT, and is the Army developmental tester for chemical and biological defense equipment, smoke, and obscurants. The DPG facilities that support the NBCCS, soldier survivability and obscurants/atmospherics testing include the following:

(1) *Combined Chemical Test Facility (CCTF)*. The Combined Chemical Test Facility (CCTF) consists of an administration area and laboratory facilities. The CCTF has 27 laboratories with 17 of the laboratories currently being certified for chemical agent use. The 17 laboratories have from one to four chemical fume hoods per laboratory. All laboratories allow testing to be performed at ambient temperature and humidity. Specially constructed test fixtures can be placed in the fume hoods to conduct temperature and humidity-controlled testing. A fume hood is 5 ft wide, 5 ft high, and 3 ft long. When multiple hoods are in one laboratory, the hoods have pass through doors between the hoods. The hoods have controllers to maintain a 100 ft/min velocity.

(2) *Marvin Bushnell Materiel Test Facility (MTF)*. The Marvin Bushnell Materiel Test Facility (MTF) is an environmentally controlled containment chamber for testing with chemical agents and simulants. MTF consists of three chambers, the multi-purpose test chamber, closed system chamber, and agent transfer chamber.

(a) The multi-purpose test chamber is a 50 ft long, 50 ft wide, and 30 ft high stainless steel chamber and is certified for use of live chemical agents. The chamber can also use chemical/biological vapors and aerosols for testing. It has a 16 ft wide by 24 ft high door, which can accommodate any military equipment that meets NATO shipping requirements, including fighter aircraft, helicopters, and ground vehicles. MTF is an air-tight chamber. The environmentally controlled glove box has a range from -40 °C to 60 °C with 5 percent to 95 percent relative humidity (RH). It can contain up to 1,000 mg/m³ concentration of agent and purge at 13,000 cubic feet per minute (CFM). The chamber has a 5-ton pneumatically driven bridge crane.

(b) The closed system chamber is 25 ft long, 250 ft wide, and 25 ft high stainless steel chamber. It has pneumatically sealed air locks and can purge at 5,300 CFM. The environmentally controlled glove box ranges from -40 °C to 60 °C with 5 percent to 95 percent RH.

(c) The agent transfer chamber is 25 ft long, 25 ft wide, and 30 ft high. The chamber has two fume hoods, an agent storage vault and a glove box test area.

g. The superchamber is 16 ft by 25 ft by 10 ft high (only 8 ft of working space). The chamber is capable of testing from -10 °F to 130 °F. The chamber has a total of 16 glove ports along both sides. The superchamber is all stainless steel. One end of the chamber has a foldable work table. The chamber will accommodate dissemination of chemical

agents as vapor or aerosol droplets. The air inside of the chamber can be exhausted through a sacrificial filter system. The superchamber is actually located within a chamber that has its own engineering controls. Entrance can be accomplished through either end of the superchamber.

h. Recently remodeled using high-tech control systems, the defensive test chamber, a 30 ft by 50 ft by 30 ft high stainless steel chamber, is used for testing with simulants, and can replicate a variety of environmental conditions. Temperatures inside the defensive test chamber can range from -20 °F to 120 °F, with 0–95 percent RH. The chamber can be operated as a wind tunnel by increasing the wind speed, thereby providing a good mixture of simulant vapor clouds. Testers can maintain wind speed at 5.4 mph at 60 percent fan speed and 7.5 mph at 80 percent fan speed.

i. The Decontamination Pad consists of a concrete pad on a raised earthen mound. The pad has a raised rim around its perimeter and through the center of the pad. The pad is sloped to allow liquids to flow into sealed troughs for collection. The troughs have a pump for removal of liquids. There are lights surrounding the pad to allow testing at night. The pad also has a curtain system to minimize spray from escaping into the environment. The pad is split into two equal sides that are 40 ft by 60 ft. Vehicles can be driven onto each side of the pad but not from one side directly onto the other side.

j. The Lothan Solomon Life Sciences Test Facility (LSTF) is a 32,000 square foot facility that has Biosafety Level 2 and 3 (BL-2 and 3) laboratories and chambers enabling testing and aerosolization of simulated and actual agents of biological origin (ABO). State of the art infrastructure, chambers, and technical expertise of the Life Science Division provides a current and versatile facility for T&E of biological detection components and systems. The testing regime includes laboratory testing, simulated environmental aerosol challenges in test chambers and controlled outdoor aerosol challenges. Test items may be challenged with ABOs or simulants, in liquid or aerosol form, in indoor chambers. Tests are conducted only with simulants on the outdoor test grids. There are currently over twenty ABOs in use in the laboratory. Included is *Yersinia pestis*, *Francisella tularensis*, *Coxiella burnetii*, *Bacillus anthracis*, Venezuelan Equine Encephalitis virus, *Botulinum* toxin (BOT), Staphylococcal Enterotoxin B (SEB), and ricin. Laboratory, chamber, and field testing combine to provide baseline characteristics, operating parameters and detection thresholds for biological sampling and detection devices. The LSTF was designed with two environmentally controlled chambers for challenging the SUT with aerosolized biological test agents: the Aerosol Simulant Exposure Chamber (ASEC) and the Containment Aerosol Chamber (CAC).

(1) The ASEC is a 13 ft by 12 ft by 11.5 ft stainless steel chamber in which temperature, RH, and simulant concentration are controlled and maintained. Temperatures ranging from -5 °C to 40 °C and relative humidities ranging from ambient to 100 percent can be maintained. The ASEC has an air mixing and computer controlled dissemination system enabling the repetitive generation of consistent and homogenous simulant aerosol clouds. Battlefield interferents can be introduced into the ASEC to challenge the SUT, but at this time, there is no system to quantitatively control their dissemination or measure concentration.

(2) The Containment Aerosol Chamber (CAC) is a 5 ft by 5 ft by 16 ft stainless steel containment chamber in which temperature, RH, and ABO concentration can be controlled and maintained. Temperatures ranging from -5 °C to 40 °C and RHs ranging from 0 percent to 100 percent can be maintained. The CAC is equipped with air mixing and biological agent dissemination capabilities in addition to BL-3 containment. All incoming and exhaust air is HEPA filtered and work is performed utilizing glove ports and uniquely designed standup half-suits. Interferents can be introduced and tested but control of concentration is limited.

(3) The environmental test chamber located in the LSTF is used for the biological simulant (*Bacillus subtilis niger* var. (BG) and nuclear fallout simulant (ZnS (FP)). The test chamber is 1.5 meter high by 1.5 meter wide by 1.5 meter long and is capable of controlling temperature (-20 °C to +100 °C) and humidity (0 to 100 percent).

k. Soldier survivability tests and facilities follow.

(1) *Man-in-Simulant Test*. The man-in-simulant test (MIST) provides data to characterize and evaluate the chem-bio protective clothing and equipment system performance in vapor challenges for both local and systemic effects and identifies any conditions associated with increased vapor penetration. The MIST is conducted in the Defensive Test Chamber. Two types of samplers are used during the system test. Passive Sampling Devices are placed in designated locations to measure the total amount of simulant that penetrates the protective system. Real-Time Samplers Miniature Infrared Analyzers provides a near real-time measurement of challenge concentrations.

(2) *Aerosol testing*. Provides data to characterize and evaluate the system performance of protective suits/equipment in aerosol challenges for both local and systemic effects; identify any conditions associated with increased aerosol penetration. A challenge aerosol (that is, simulant) concentration is generated using a fluorescently tagged inert particles in a specially designed test chamber while wearers perform a fixed set of exercises. Upon exiting the chamber, the wearers are sampled using a liquid extraction from the skin, the extracted fluid is analyzed for the amount of simulant present. Wearers are also photographed under black light to identify the relative amounts of simulant present at each sampling site.

(3) *Smartman mask tester*. This fixture is used to test chemical protective masks by placing them on a zinc head form that has been constructed to simulate a soldier's head and to allow installation of a protective mask. A breather pump is used to draw air into the head form, simulating human breathing. A peripheral seal, mounted in a channel on the head form, is inflated to compress against the inside of the mask, ensuring an optimal mask/fixture seal. This head

form is mounted inside a temperature and humidity controlled chamber that is capable of containing chemical agent vapors and is challenged at specified liquid for vapor, or a combination of both, agent concentration. Sampling locations at the nose and eye allow the vapor concentration inside the mask to be monitored. Challenge concentration is measured by a near-real time instrument.

(4) *Protection factor (PF) test.* The protection factor (PF) test determines how well the protective mask fits the face of the individual, since completeness of the face seal is critical parameter for respiratory protection. The PF test examines the face seal leakage of the protective mask while each wearer performs 10 standard, 1-minute exercises surrounded by a corn oil, aerosol cloud in a chamber. The aerosol count within the mask is constantly monitored via sample tubes inserted through the mask's side voicemitter and drink tube monitoring eye and nasal cavities, respectively. The aerosol measurements are made using a forward light scattering laser photometer driven by a data acquisition system.

W-22. Obscurants survivability testing

DPG conducts testing to address the effects of obscurants and survivability of systems in obscurants. These are field tests that provide data to determine whether the system can operate and survive in an obscurant environment.

W-23. Survivability tester responsibilities

a. ATEC's DTC, as the survivability tester, will participate in the T&E WIPT and other working groups so as to provide expertise needed to develop a survivability test program to meet the needs of the system evaluator. When reviewing program documentation, the survivability tester will identify survivability test concerns to include, absence of testing in the TEMP, absence of testable requirements in the requirement documents and inadequate test procedures or facilities. ATEC's DTC will provide appropriate input to the TEMP needed to identify the survivability testing to be performed.

b. ATEC's DTC will coordinate with the MATDEV/PM to obtain detailed information on the system description needed to assess survivability and to implement a thorough and carefully conducted test. A cost estimate will be prepared for the customer and funding provided prior to start of testing. A test plan will be prepared and coordinated with the system evaluator and other members of the T&E WIPT as appropriate. Testing will be conducted in accordance with the test plan. Test Incident Reports (TIRs) will be provided to document incidents as they occur. Interim test results may be provided to the T&E WIPT as needed. A test report will be issued at the conclusion of the survivability test program to support the system evaluation and program decision process.

W-24. Summary

It is neither practical nor feasible to make every system/subsystem fully survivable on the battlefield. The program sponsors, in coordination with the system evaluator, developmental and operational testers, MATDEV, and CBTDEV must assess the risk associated with each of the survivability areas to determine whether the risk is acceptable. Safety of personnel and munitions is critical and protection is generally required to preclude unsafe situations. The most stringent intended environment will be used to identify system shortcomings.